CALCULATION OF DOSES FROM UNPLANNED AIRBORNE RELEASES

Purpose

This Air Quality Group procedure describes the use of the models HOTSPOT, MIDAS, CAP88, GENII, and other dispersion programs for calculating doses from unplanned or off-normal radionuclide releases to the air from the Los Alamos National Laboratory.

Scope

This procedure applies to the calculation of radiological doses from unplanned releases for compliance with DOE standards regarding radioactive air effluents. Such dose assessments may also be required to provide information for occurrence investigation, public affairs, etc. The Laboratory maintains a separate program for responding to and managing accidents and emergencies regarding radioactive releases.

In this procedure

Hazard Control Plan

The hazard evaluation associated with this work is documented in HCP-ESH-17-Office Work.

Signatures

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11/10/99

General information about this procedure

Attachments

This procedure has the following attachments:

Number	Attachment Title	No. of pages
1	Technical Areas and Related Meteorological Towers	1
2	Map of Meteorological Tower Locations	1
3	Example PUFFI output	1

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description of Changes
0	9/24/96	New document.
1	11/4/99	Added source effects and PUFFI model discussion.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- individual responsible for calculating dose

Annual retraining is required and will be by self-study (“reading”) training and test case computer runs of models.

Training method

The training method for this procedure is **on-the-job** training by a previously-trained individual and is documented in accordance with the procedure for training (ESH-17-024).

Prerequisites

In addition to training to this procedure, the following training is also required prior to performing this procedure:

- ESH-17-501 (if CAP88 model is used)
- read HOTSPOT users manual

General information, continued

Definitions specific to this procedure

Unplanned release: An unexpected release of radioactivity into the atmosphere from a LANL operation.

Facility critical receptor: The nearest public receptor (person or location) at which the maximum dose occurs

References

The following documents are referenced in this procedure:

- ESH-17-024, "Personnel Training"
- ESH-17-407, "Altering MIDAS Scenarios"
- ESH-17-501, "Dose Assessments Using CAP88"
- DOE/EH-0070, "External Dose-Rate Conversion Factors for Calculation of Dose to the Public"
- DOE/EH-0071, "Internal Dose-Rate Conversion Factors for Calculation of Dose to the Public"
- UCRL-MA-106315, HOTSPOT users manual
- DOE/TIC-11223, "Handbook on Atmospheric Diffusion"
- MIDAS users guide

Note

Actions specified within this procedure, unless preceded with "should" or "may," are to be considered mandatory guidance (i.e., "shall").

Selecting model to use

Release duration

Use the duration and radioactive material content of the unplanned release to determine the most appropriate dose assessment model to use to calculate the dose. The dose is properly calculated using the actual meteorological conditions that existed during the time of the release. The table below shows how the release duration affects the choice of dose assessment models. If the duration of the release is unknown, the most conservative approach would be to use the HOTSPOT code.

Release Duration	Model
0 to 15 min	MIDAS or HOTSPOT
15 min to 24 hours	MIDAS or PUFFI
over 24 hours	MIDAS, GENII, or other(s)

Different models have different radionuclide libraries available and thus some are more limited than others.

Pre-calculation of dose

Prior to using a model, a fast "back of the envelope" calculation should be performed to provide a quick assessment of the situation. For such calculations, the following parameters are recommended since these provide "worst case" modeling conditions: an atmospheric stability category of "E", wind speed of 2 m/s, and a release height of 10 m.

Use of MIDAS model

For some releases, the emergency response model, MIDAS, should be used to calculate potential doses. The MIDAS model constructs diagnostic wind fields to calculate transport and dispersion and the subsequent doses. However, many unplanned releases do not invoke the use of the MIDAS model.

The MIDAS model can be utilized for many types of site-specific releases: Lab facility accidents, TA-18 accident, and transportation accidents. For each scenario, the following radionuclides are available in the code:

- Default: Pu-238, Pu-239, U-235, HTO, and HT.
- TA-18: Weapons grade Pu and U.
- Transportation: Weapons grade Pu, heat source Pu.

Selecting model to use, continued

Use of HOTSPOT model

HOTSPOT uses a one-pass standard gaussian plume algorithm with user-supplied values for wind speed, atmospheric stability, and particle size distribution. The code has an extensive radionuclide library but allows only one radionuclide to be modeled per run. When using HOTSPOT, the dose conversion factors may be input directly into the code.

Use of CAP88 model

CAP88 was originally developed by EPA to demonstrate annual compliance to EPA's public dose limit, not for running unplanned releases; the dose calculated by CAP88 assumes a year-long exposure to the radionuclide(s). However, CAP88 is useful because it uses a multiple-pass standard gaussian plume algorithm and an input file of wind speed, direction, and atmospheric stability in a joint frequency array. This meteorological input can be easily constructed for releases that occur over a sufficiently long enough time period, for example a one week stack sampling period. **Do not use CAP88 for releases lasting less than 24 hours.**

Use of GENII model

The DOE model GENII uses an atmospheric dispersion algorithm similar to CAP88, and may be used as an alternative to the CAP88 model discussed in this procedure. GENII uses the same meteorological data (different file format) required by CAP88. In addition, GENII allows for acute releases and has a building wake correction, and thus may be more appropriate in some cases.

Use of gaussian plume models

In the case where the radionuclide released is not part of the dose assessment model's library, use a calculator, spreadsheet, or other computer version of a gaussian plume model to calculate the air concentration at the receptor site(s). Then apply the appropriate dose conversion factors available in DOE/EH-0070 and DOE/EH-0071 for each respective radionuclide released.

A wide number of accidental release and atmospheric transport models have been developed by various organizations for diverse purposes. If deemed appropriate, these models could be utilized by an advanced user. Some of these models include ISCST3, MACCS2, RADTRAN4, RAMS, ERAD, and GAUS1.

Selecting model to use, continued

Use of PUFFI model

ESH-17 has developed a new model, PUFFI, which has certain features not available in other gaussian plume models listed above. PUFFI can employ a less empirical method to calculate diffusion by utilizing the direct measures of atmospheric turbulence gathered by ESH-17's monitoring program. PUFFI also can adjust for the elevation of receptors in relation to the release point. Also, parameters can be selected to account for the rugged terrain effects on dispersion for LANL sources.

Obtaining meteorological data for model

Met towers

After selecting the model, obtain the meteorology data required for the model. Use the appropriate tower for the location of the release; see Attachment 1 to determine the closest tower for each technical area. **Note**: All meteorological data records are time stamped with mountain standard time.

There are four mesa-top towers and one canyon tower maintained by the Air Quality Group: TA-6, TA-49, TA-53, TA-54, and TA-41, respectively. The table below lists the measurement heights of the weather variables of interest for each tower. For most dose calculations, the data from the 11.5-meter height should be used in the dose assessment.

Tower Location	Wind Measurement Levels (m)
TA-6	11.5, 23, 46, and 92
TA-49	11.5, 23, and 46
TA-53	11.5, 23, and 46
TA-54	11.5, 23, and 46
TA-41	11.5 and 23

Required data

Meteorological data required to perform the dose assessments includes wind speed, wind direction, and measures of atmospheric stability and the respective frequency of each of these parameters during the event. Each dose assessment method has a different format for the data input.

If the wind field has some spatial variation to it at the time of release, an interpolated wind field from nearby towers should be used. The MIDAS wind field display is useful in providing this information (see the example given in Attachment 2).

MIDAS

The MIDAS model will automatically obtain the wind field for the period of interest.

Obtaining meteorological data for model, continued

CAP88

A data input file must be constructed for a CAP88 dose assessment. Follow ESH-17-501 to provide to the meteorological technician the start and end time and date, and the meteorological tower of interest to allow construction of the input file. If you have access to the Internet, the data can also be downloaded directly from ESH-17's model input home page at http://weather.lanl.gov/cgi-bin/starfilerequest.pl.

HOTSPOT, PUFFI or gaussian plume

The necessary data can be obtained from the Weather Machine home page on the Los Alamos world wide web server by selecting the "long form option." If the release occurred more than 12 hours in the past, data can also be obtained at the address http://weather.lanl.gov/cgi-bin/datarequest.pl, or by contacting a group meteorologist. The PUFFI program reads the raw data files generated by the web site; an example of the input format is included in the attachment.

Releases from canyons

The Air Quality group and the Geoanalysis group (EES-5) are participating in ongoing canyon wind studies of Los Alamos and Pajarito Canyons. Based on preliminary measurements, the flow at the mesa top using the Weather Machine's wind field displays can be used to evaluate the potential wind conditions in these canyons. The potential wind conditions are:

- down-canyon stable flow
- up-canyon unstable flow
- cross-canyon unstable flow

There can also be a "rotor" situation, which essentially is either "up-canyon unstable flow" or "down-canyon unstable flow." A meteorologist should be consulted to determine which condition is occurring and the most appropriate wind data to use.

Source effects

There are two important source effects the dose assessor should be aware of, and make adjustments accordingly. These are stack downwash and building wake effects, both of these effects can lower the effective release height of an elevated source and increase ground level concentrations close in to the release point. These effects are discussed more completely in the reference DOE/TIC-11223, "Handbook on Atmospheric Diffusion."

Obtaining meteorological data for model, continued

Steps to calculate downwash

To determine if the effective stack height should be reduced for stack downwash, follow these steps:

Step	Action
1	Determine the mean wind speed u_o (m/s) from the meteorological data set.
2	Divide the stack exit velocity w_o (m/s) by the mean wind speed u_o obtained from step 1. If the resulting value is greater than 1.5, there is no need to adjust the effective stack height. Skip the remaining steps.
3	If the value obtained in step 2 is less than 1.5, then the downwash distance h_d (m) is calculated with the following equation: $H_d = 2 * (w_o / u_o – 1.5) * D$ Where D is the internal stack diameter.
4	Subtract the value of h_d obtained in step three from the physical stack height to obtain the new effective release height to be used in the modeling, e.g. $h_{effective} = h_{physical} - h_d$
5	If an advanced model is used, it may not be necessary to adjust for stack downwash.

Steps to calculate building wake

Building wake is another source effect that may need to be accounted for. If the effective release height (calculated above) is less than 1.5 times the height of surrounding buildings or other large structures, it may be worthwhile to adjust the effective release height. The steps to calculate a new effective height are:

Step	Action
1	Determine the height of the surrounding buildings or structures. If the effective release height of the stack (after downwash) is at least 1.5 times the maximum building height, skip the remaining steps
2	If h_d is less than the height of the surrounding structures, the effective release height is calculated with the following: $h_{effective} = h_d – 1.5 * g$ Where g is the smaller value of either the width or length (m) of the building(s) evaluated.
3	Or if h_d is greater than the height of the surrounding buildings or structures (but less than 1.5 times) then the effective release height is calculated using: $h_{effective} = 2* h_d – (H + 1.5 * g)$ Where g is the smaller value of either the width or length (m) of the building(s) evaluated and H is the maximum building height.
4	If an advanced model is used, it may not be necessary to pre-calculate building wake effects.

Calculating the dose

Receptor location

Once the model is selected and the meteorological data obtained, the radiological doses can be calculated. There will usually be a number of locations or receptors of interest that require a dose to be calculated. The most important is the maximum off-site or facility boundary (with public property) dose, whichever is greater. The modeler may have to make a number of successive dose runs to determine the actual location of maximum off-site dose.

Steps to calculate the dose

Follow the steps in the previous chapters to select a model and obtain the meteorology data. Follow these steps to calculate the dose:

Step	Action
1	In relation to the point of release, determine the distance and direction of the potential critical receptors as well as the current LANL-wide critical receptor location.
2	Determine the appropriate release height, stack diameter and exit velocity to use for the model. **Note:** These data are already included in MIDAS. HOTSPOT also requires input on the type of release; e.g., stack, open fire, explosion.
3	Using the selected model, wind, and release point data, calculate the dose(s) at the locations specified in step 1. For the CAP88 model, follow procedure ESH-17-501 to run the model. **Note:** HOTSPOT will only provide an inhalation dose. Immersion and ground shine dose can be calculated using the air and ground concentration values provided by HOTSPOT and the appropriate dose conversion factors. For noble gases, HOTSPOT calculates immersion dose only. The PUFFI model currently only calculates a time integrated concentration. The concentrations can be converted to dose by following the guidance in DOE/EH-0070 and –0071.
4	Report the doses to the appropriate parties, such as ESH-17 managers. Document the doses for later inclusion in the annual site environmental report to DOE or as necessary.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted as records to the records coordinator:

- Copy of output generated and/or calculations made
- Official memorandum to ESH-17 file
- Description of Release for EPA and DOE Annual Reports

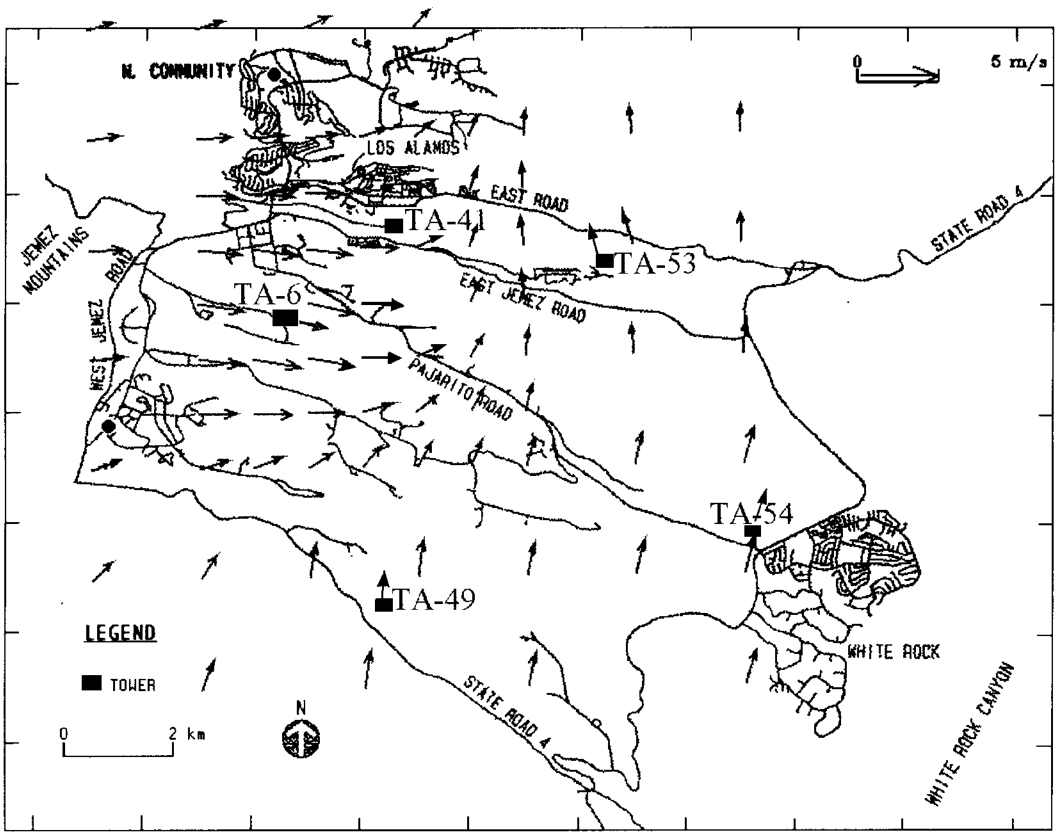
LABORATORY TECHNICAL AREAS AND RELATED METEOROLOGICAL TOWERS

TA	Tower
2*	TA-41 and TA-53
3	TA-6
5	TA-53
6	TA-6
8	TA-6
9	TA-6
11	TA-6
14	TA-6
15	TA-49
16	TA-6
18*	TA-41 and TA-54
21	TA-53
22	TA-6
28	TA-6
33	TA-54 or TA-49
35	TA-6
36	TA-49 or TA-54
39*	TA-41 and TA-49 or TA-54

* Denotes a canyon-level Technical Area

TA	Tower
40	TA-6
41*	TA-41 and TA-6 or TA-53
43	TA-6
46	TA-53
48	TA-6
49	TA-49
50	TA-6
51	TA-53
52	TA-6
53	TA-53
54	TA-54
55	TA-6
59	TA-6
60	TA-6
61	TA-6
63	TA-6
64	TA-6
69	TA-6

MAP OF METEOROLOGICAL TOWER LOCATIONS



Also shown is a MIDAS generated wind field (11:15 MST on 11/09/95). Note the dramatic change in direction mid-way over the Pajarito Plateau. Thus care should be exercised when selecting meteorological conditions for HOTSPOT runs.

EXAMPLE PUFFI FILES

Example meteorological data input to PUFFI

date	time	doy	spd1	sdspd1	dir1	sddir1	w1	sdw1	temp1	swdn
10/07/1998	13:15	280	4.4	159	15	0.14	0.47	16.6	791	
10/07/1998	13:30	280	4.8	167	14	0.18	0.56	16.9	773	
10/07/1998	13:45	280	4.7	171	21	0.23	0.64	17.2	753	
10/07/1998	14:00	280	4.7	166	17	0.19	0.57	17.5	706	
10/07/1998	14:15	280	4.3	176	15	0.07	0.50	17.5	702	
10/07/1998	14:30	280	4.0	177	21	0.26	0.61	18.2	578	
10/07/1998	14:45	280	4.0	200	19	0.04	0.50	18.2	631	
10/07/1998	15:00	280	4.2	183	15	0.09	0.51	18.3	510	
10/08/1998	09:15	281	1.2	73	25	0.15	0.41	12.0	619	
10/08/1998	09:30	281	1.4	74	22	0.07	0.35	12.6	522	
10/08/1998	09:45	281	1.5	92	28	-0.03	0.32	12.8	516	
10/08/1998	10:00	281	1.4	148	18	0.15	0.31	13.1	345	
10/08/1998	10:15	281	1.4	132	32	0.16	0.36	13.1	513	
10/08/1998	10:30	281	1.1	147	33	0.03	0.34	13.6	580	
10/08/1998	10:45	281	1.4	101	30	-0.12	0.34	14.4	794	
10/08/1998	11:00	281	1.5	61	30	0.03	0.39	15.4	812	
10/09/1998	07:15	282	0.9	301	79	-0.04	0.15	10.2	191	
10/09/1998	07:30	282	1.7	342	52	-0.06	0.20	10.9	227	
10/09/1998	07:45	282	0.8	5	78	-0.01	0.19	11.3	210	
10/09/1998	08:00	282	0.7	4	67	-0.01	0.09	11.6	252	
10/09/1998	08:15	282	0.6	38	32	-0.00	0.11	11.9	294	
10/09/1998	08:30	282	1.3	67	34	0.04	0.26	12.0	460	
10/09/1998	08:45	282	1.6	57	34	0.01	0.29	12.4	493	
10/09/1998	09:00	282	1.3	64	28	0.04	0.39	12.8	471	
10/09/1998	09:15	282	1.2	80	31	-0.07	0.27	13.1	583	
10/09/1998	09:30	282	1.3	75	37	0.18	0.46	13.9	623	
10/09/1998	09:45	282	1.3	109	42	0.19	0.38	14.8	661	

```
10/09/1998 10:00 282   1.7  143     21  0.08  0.40  15.1   694
```

Example Source Term and Receptor Input File to PUFFI

```
TA21-209-1   20.0      22.9      1.2       12.0
center        0.0       0.0       0.0
TA-21-209-1   -385253.5 3970752.3 2171.0
sampler21-71  -384708.9 3971003.5 2175.7
sampler21-72  -384775.6 3970961.0 2173.5
sampler21-73  -384924.8 3970848.2 2172.3
sampler21-74  -384747.4 3970736.2 2175.4
sampler21-75  -384821.3 3970716.1 2175.4
TA-21 #20     -384404.2 3970970.0 2185.4
```

Example Output From PUFFI

```
gamma% a.out
  q=   20.0    h=   22.9    d=    1.2   v=   12.0
 ------------------------------------------------------
x dist= -544.6   y dist=  251.2   radial=  599.7   recep Z =    4.7
sampler21-71 =receptor location, the concentration is  2.54E+02 pCi/m3.
 ------------------------------------------------------
x dist= -477.9   y dist=  208.7   radial=  521.5   recep Z =    2.5
sampler21-72 =receptor location, the concentration is  3.17E+02 pCi/m3.
 ------------------------------------------------------
x dist= -328.7   y dist=   95.9   radial=  342.4   recep Z =    1.3
sampler21-73 =receptor location, the concentration is  1.46E+03 pCi/m3.
 ------------------------------------------------------
x dist= -506.1   y dist=  -16.1   radial=  506.4   recep Z =    4.4
sampler21-74 =receptor location, the concentration is  1.12E+03 pCi/m3.
```

----

x dist= -432.2   y dist= -36.2   radial= 433.7   recep Z =   4.4

sampler21-75 =receptor location, the concentration is 1.78E+03 pCi/m3.

----

x dist= -849.3   y dist= 217.7   radial= 876.8   recep Z =   14.4

TA-21 #20   =receptor location, the concentration is 3.59E+02 pCi/m3.

gamma%